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CAIO FOSSALUSSA DA SILVA

AVALIAÇÃO IN VITRO DA INFLUÊNCIA DA ESPESSURA CORTICAL ÓSSEA NA ESTABILIDADE PRIMÁRIA EM IMPLANTES CONVENCIONAIS E DE TAMANHO CURTO

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Trabalho de conclusão de curso apresentado à Faculdade de Odontologia da UFU como requisito parcial para obtenção do título de Graduado em Odontologia.

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SUMÁRIO

Resumo

O objetivo deste estudo in vitro foi avaliar a influência da espessura cortical na estabilidade primária de implantes curtos e convencionais com dois tipos de conexão protética. Setenta e dois implantes foram usados. Esses implantes foram colocados em blocos de poliuretano que simulavam tecido ósseo de baixa densidade (osso tipo IV), com duas alturas corticais ósseas (osso tipo I): 1mm e 3mm. Os implantes foram divididos em 6 grupos (n=12), de acordo com o tipo de conexão protética (hexágono externo-HE e cone morse-CM) e tamanhos de implante (convencional: 4x10mm; curto: 5x5mm; 5,5x5mm; 5x6mm; 5,5x6mm). As análises de torque de inserção (TI) e frequência de ressonância (FRA) foram realizadas para avaliar a estabilidade primária dos implantes. Todos os implantes instalados em blocos com 3mm de espessura cortical apresentaram maior TI do que aqueles instalados em 1mm. Os implantes CM de tamanho curto tiveram um TI mais alto do que os implantes convencionais da mesma conexão. Os implantes HE de tamanho curto mostraram menos TI do que os implantes CM de tamanho curto em blocos com 3 mm de cortical. Em blocos com 1 mm de cortical, os implantes HE convencionais tiveram um TI mais alto em comparação com os implantes HE de tamanho curto. Os implantes de tamanho convencional apresentaram maiores valores de FRA apesar da espessura da cortical nos blocos. A maior espessura da cortical óssea e o tamanho dos implantes proporcionam maior estabilidade primária dos implantes independentemente da conexão protética.

Palavras-chave: conexão de implantes; macroestrutura de implantes; estabilidade primária.

Introdução

A utilização de implantes na reabilitação de pacientes totalmente e parcialmente edêntulos criou uma alternativa mais conservadora no tratamento protético pois os elementos dentários perdidos podem ser substituídos com grande previsibilidade e estabilidade, com ausência de desgaste de dentes adjacentes para confecção de próteses fixas (AL-QURAN FA, AL-GHALAYINI RF, 2011) e promovendo maior satisfação aos pacientes (ZEMBIC A, 2014). Entretanto, a instalação de implantes é dependente de uma quantidade de tecido ósseo que permita a obtenção de um posicionamento adequado sem causar injúrias a estruturas nobres presentes nos maxilares (ARLIN ML, 2006).

Algumas manobras têm sido indicadas para resolução da limitada disponibilidade óssea tal como a elevação do seio maxilar (BOYNE PJ, 1980), utilização de blocos de enxerto onlay (MISCH CM, 1996), a lateralização do nervo alveolar inferior (FRIBERG B, IVANOFF CJ, 1992) e a distração osteogênica (CHIAPASCO M, ZANIBONI M, 2007). Entretanto, tais procedimentos cirúrgicos são complexos e estão relacionados a um maior desconforto ao paciente, ao aumento da possibilidade de lesões de estruturas nobres e ao aumento do tempo para iniciar os procedimentos reabilitadores (FELICE P, PISTILLI R, PIATTELLI M, SOARDI E, CORVINO V, 2012; VASCO MA, HECKE MB, 2011).

Os implantes curtos têm sido indicados com uma alternativa menos traumática para a reabilitação de áreas com pobre disponibilidade óssea (ANITUA E, ORIVE G, AGUIRRE JJ, 2008; FELICE P, PISTILLI R, PIATTELLI M, SOARDI E, CORVINO V, 2012; SCHINCAGLIA GP, THOMA DS, HAAS R, TUTAK M, GARCIA A, TAYLOR TD, 2015). Estudos têm demonstrado que o índice de sucesso de implantes curtos instalados é semelhante aos dos implantes convencionais (CALVO-GUIRADO JL, LOPEZ TORRES JA, DARD M, JAVED F, PEREZ-ALBACETE MARTINEZ C, 2015; FELICE P, PISTILLI R, PIATTELLI M, SOARDI E, CORVINO V, 2012; SCHINCAGLIA GP, THOMA DS, HAAS R, TUTAK M, GARCIA A, TAYLOR TD, 2015). Entretanto, tem sido relatado que o sucesso de implantes é altamente dependente da obtenção da estabilidade primária (JAVED F, 2015; MORASCHINI V , V ELLOSO G, LUZ D, 2015; QUEIROZ TP, AGUIAR SC, MARGONAR R, DE SOUZA FALONI AP, GRUBER R, 2015) e que fatores como o desenho do implante (MOHLHENRICH SC, HEUSSEN N, ELVERS D, STEINER T, HOLZLE F, 2015), a densidade óssea (MARTINEZ H, DAVARPANAH M, MISSIKA P, CELLETTI R, 2001) e o torque de inserção (TRISI P, PERFETTI G, BALDONI E, BERARDI D, COLAGIOVANNI M, 2009) têm demonstrado influenciar esse parâmetro.

Levando-se em consideração que implantes curtos podem ser utilizados em sítios de baixa densidade óssea como a região posterior da maxila para se evitar cirurgias de elevação de seio maxilar, se faz necessário a obtenção de implantes com desenho adequado que possam obter estabilidade primária mesmo nessas regiões de baixa densidade. Além disso, a quantidade de osso cortical nessas região podem alterar a estabilidade primária nesses sítios. Dessa forma, o objetivo do estudo foi avaliar a estabilidade primária de implantes através da análise de frequência de ressonância e torque de inserção dos implantes com tamanhos convencionais e curtos com conexões protéticas de hexágono externo e cone morse em blocos de poliuretano com densidades semelhantes ao osso tipo IV e com três espessuras de corticas ósseas.

Capítulo I

Original Research: In vitro evaluation of the influence of bone cortical thickness on the primary stability of conventional and short sized implants.

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Abstract

The aim of this in vitro study was to evaluate the influence of the cortical thickness on the primary stability of short and conventional-sized implants with two types of prosthetic connection. Seventy-two implants were used. These implants were placed in polyurethane blocks that simulated low-density bone tissue (type IV bone), with two bone cortical heights (type I bone): 1mm and 3mm. The implants were divided into 6 groups with 12 implants each according to the type of prosthetic connections (external-hexagon -EH and morse taper- MT) and implant sizes (conventional-4x10mm and short 5x5mm; 5.5x5mm; 5x6mm; 5.5x6mm). Insertion torque (IT) and resonance frequency analyzes (RFA) were performed to evaluate the primary stability of the implants. All implants installed in blocks with 3mm of cortical thickness showed greater IT than those installed in 1mm. The short-sized MT implants had a higher IT than conventional implants of the same connection. Short-sized EH implants showed less IT than short-sized MT implants in blocks with 3mm of cortical. In blocks with 1mm of cortical, conventional EH implants had a higher IT compared to short-sized EH implants. The conventional sized implants presented higher RFA values despite the thickness of the cortical in the blocks. The greater bone cortical thickness and implants size provides greater primary stability of the implants regardless the prosthetic connection.

Keywords: Implants connection; implants macrostructure, primary stability.

Introduction

The oral rehabilitation with implants is an increasingly common practice in the field of dentistry, and the success of this type of rehabilitation depends on the success of the osseointegration process (Norton et al., 2017; Valente et al., 2019). One of the factors that must be taken into account for the osseointegration process occurs satisfactorily is to obtain good primary stability after the implant's placement (Castellanos-Cosano et al., 2019).

Although primary stability is obtained in the most part of native bone sites in healthy patients (Faot et al., 2014; Valente et al., 2019), in clinical conditions where implant installation occurs in areas of bone with poor density, the implant stabilization is more difficult to obtain (Castellanos-Cosano et al., 2019; Kim et al., 2019). In addition to the reduced bone density, it is common clinical situations with reduced bone height where conventional size implants (> 10mm) cannot be installed directly in native bone (Castellanos-Cosano et al., 2019; Trinches et al., 2019).

In this context, the modifications on the implant macrostructure have been developed to facilitate the achievement of primary stability in these sites (Huang et al., 2014; Alonso et al., 2018; González-Serrano et al., 2018). Parameters such as the connection, thread, and platform design have been improved, making it possible to place implants in borderline conditions (Anil & Aldosari, 2015; González-Serrano et al., 2018; Kim et al., 2019).

Then, the objective of this study was to evaluate the influence of implant length and prosthetic connection on the primary stability of implants placed in synthetic polyurethane blocks with poor density (mimetizing type IV bone) and different thicknesses of the high density (mimetizing the cortical bone) through the frequency of resonance and implant insertion torque.

Material and methods

Experimental design

Seventy-two conical implants (Implacil de Bortoli, São Paulo, SP, Brazil) were used in this study. The implants presented external hexagon (EH) or morse taper (MT) connections and were allocate into 6 groups according to the implants size and diameter: HE (n=36): 4x10, 5x5 and 5x6 mm; and CM (n = 36): 4x10, 5.5x5 and 5.5x6 mm. Twelve implants from each group were installed in polyurethane blocks simulating type IV density, with two bone cortical heights (1 or 3 mm) (Figure 1).

Implants placement

The implants were inserted into the specimens by a single operator, following the sequence of surgical drills recommended by the manufacturer. In order to evaluate the primary stability of implants in conditions similar to the bone tissue, specimens made of polyurethane (Nacional Ossos, Jaú-SP, Brazil) with density corresponding to type IV bone (15 PCF or 0.24 g/cm3) were used. The cortical bones had two different thicknesses (1 or 3 mm) with density similar to type I bone (40 per cubic foot (PCF) / 0.64 g/cm3). The specimens presented length of 9.9 cm (L), width of 2.55 cm (L) and height of 2.02 cm (H) in order to allow the installation of 6 implants per block (Figure 2). In total, 12 blocks were made: 6 blocks with 1mm and 6 blocks with 3mm of cortical density thickness.

In order to facilitate the standardization during the installation of the implants into the polyurethane blocks, two surgical guides were made in colorless acrylic resin containing the same width and length of the blocks, which allowed the implants to be installed in the same position in all groups equidistant, keeping a distance of 1 cm between them and the edges of the blocks. Implants with EH type platform were installed with the platform at the level of the upper border of the blocks while the implants with MT connection were installed 2mm below the upper border of the blocks (Figure 2).

Evaluation of primary stability: Insertion torque and resonance frequency analysis

The primary stability of each implant was achieved through the insertion torque and the resonance frequency analysis. The insertion torque was measured in newtons (Ncm) by means of a manual torque wrench (make, model, Implacil de Bortoli, São Paulo-SP, Brazil) at the moment of implants placement in the blocks until the implant was in position at bone level for EH implants or 2mm apically from the level of upper border of the blocks for MT implants. The analysis of the resonance frequency was performed with the Osstell device (Integration Diagnostic, Göteborg, Sweden) associated with the use of a small piezoelectric transducer (SmartPegTM, Integration Diagnostics AB, Göteborg, Sweden) connected to the implant. The implant stability quotient (ISQ) was the average of the measurements performed in four faces per implant.

Statistical analysis

The Graphpad Prism 6 software (San Diego, CA, USA) was used to perform the statistical analyzes of this study. The insertion torque data not present normal distribution while the ISQ data presented normal distribution as detected by the Kolgomorov-Smirnov normality test. The comparison on the insertion torque of the different types of implants in each of the cortical thicknesses was performed by the Kruskall-Wallis test complemented by the Dunn test. The comparison of similar types of implants installed in blocks with different cortical sizes was performed by the Mann-Whitney test. Regarding the ISQ, the comparison on this parameter in the different types of implants in each of the cortical thicknesses was performed by the one-way ANOVA test complemented by the Tukey's test. The comparison of similar types of implants installed in blocks with different cortical sizes was performed by the Unpaired t-test. All tests were applied with a 95% confidence level ($p<0.05$).

Results

Insertion torque

It was showed that the greater thickness of the cortical density the greater is the implant insertion torque values, regardless of the implants size or prosthetic connection (colocar valores aqui). All implants placed in block with 3mm of cortical showed greater insertion torque compared to implants installed in the specimen with 1 mm of cortical (colocar valores ou também diferença estatística; p ?) (Table 1).

Regarding the implants size, the conventional implants with EH connection (4 x 10 mm) showed higher insertion torque compared to short-sized implants with the EH connection (5 x 5 or 5 x 6 mm) regardless of the thickness of the cortical portion of the blocks (Table 1 , p <0.05). Conversely, conventional implants with MT connection (4 x 10 mm) did not show statistically significant differences in insertion torque compared to short-sized implants (5.5 x 5 and 5.5 x 6 mm) with MT connection only for the cortical thickness of 1 mm (Table 1, p> 0.05). In addition, short-sized implants with MT connection showed statistically higher insertion torques when compared to conventional implants with MT connection in blocks with 3 mm of cortical (Table 1, p <0.05).

Regarding the prosthetic connection, the conventional EH implants showed higher insertion torque compared to MT connection. In contrast, short-sized implants with MT connection presented higher insertion torque than short-sized implants with EH connection (Table 1, p> 0.05).

Resonance frequency analysis

It was verified that thicker cortical density is related with the higher ISQ values of the implant regardless of the size of the prosthetic connection. Groups of implants installed in a specimen with 3 mm of cortical density showed higher ISQ values than implants installed in a specimen with 1 mm of cortical density, with the exception of short implants with 5.5 x 5 mm with MT connection.

Regarding the implants size, the conventional implants showed higher ISQ values than groups of short implants, regardless of the specimen's cortical thickness (Table 2, p <0.05). Regarding the type of prosthetic connection, there was a statistically significant difference only in the ISQ values for the 5.5 x 5 mm short-sized implant with MT connection when compared to the 5 x 6 mm short sized implant with EH connection (MT: 48.42 ± 1.19 versus EH: 54.54 ± 4.61, p <0.05).

Discussion

This study aimed to evaluate the effect of cortical thickness on primary stability of implants with different sizes and connections using IT or ISQ. The results clearly demonstrated that the dental implant stability was weakly influenced by the implants connection, but cortical thickness strongly increased implant stability.

Previous clinical studies have also found that higher cortical bone thickness increases initial implant stability, which is in agreement with the present study (Nkenke et al., 2003; Miyamoto et al., 2005; de Oliveira Nicolau Mantovani et al, 2018). Cortical bone thickness is important for the implant primary stability and occlusal loading force dissipation to the peri-implant bone tissue, whereas trabecular bone is of considerable importance for peri-implant bone healing (Merheb et al., 2018; Tanaka et al., 2018). It can therefore be suggested that the cortical bone thickness is a valuable resource to increase primary stability when planning to immediately load a dental implant (Merheb et al., 2018).

In clinical situations, the obtention of a good primary stability is a fundamental requisite in order to apply the immediate loading technique. It has been showed that the IT value needed to be equal or higher than 30 Ncm (Amari et al., 2019) or the ISQ value that needed to be equal or higher than 65 (Bornstein et al., 2009) to provide a safe condition to indicate the immediate loading. Furthermore, it has showed that IT lower than 10 Ncm (Walker et al., 2011) and ISQ lower than 55 is related with a delayed and failures in the osseointegration process (Chen et al., 2019). In this in vitro study, the IT of the all implants placed in the PU with 3 mm of cortical presented mean values above 40 Ncm, while the short-sized EH implants present mean values of IT lower than 30 Ncm in the PU blocks with 1 mm of cortical. In addition, only the conventional sized implants presented ISQ higher than 60 at the both types of blocks. These findings can have an important impact on the clinical protocols since the immediate load can be only indicated in conventional-sized implants with safe according to the results of this in vitro study.

Previous clinical studies have shown that short implants have success and survival rates similar to conventional implants (Palacios et al., 2018). Although our findings demonstrate a disadvantage of short implants in achieving good primary stability, this does not prevent the osseointegration event from occurring successfully, despite the fact that it occurs more slowly (Duyck et al., 2015). In fact, implants with reduced primary stability such success rates, especially when maintained without prosthetic load until the establishment of secondary stability (Norton, 2017; Chen et al., 2019).

In this study, the different prosthetic connections did not influence the primary stability of the implants. This finding is in accordance with a previous in vitro study that demonstrated that implants with different prosthetic connections did not present differences in their primary stability if the macrostructure was similar (Oliveira et al., 2016). Implants with MT connection are recommended to be inserted 2 mm below the top of the bone crest (Pessoa et al., 2017). This means that in clinical conditions with less cortical thickness, such as mimicked in the block with 1 mm of cortical thickness, the entire body of this implant was located into the less density portion of the PU block. It is likely that the conical macrostructure of the implants used have equated the stability of these implants installed at different levels in relation to the upper edge of the PU block with a thinner cortical.

The used to evaluate the primary stability in this study (IT or ISQ) should be interpreted independently since a high torque does not mean a high ISQ and vice versa (Baldi et al., 2018). Traditionally, implant primary stability was assessed either by the clinician tactile perception or by the evaluation of IT with the help of a torque wrench or a dedicated implant motor (Esposito et al., 2007). Indeed, the IT is still an easily obtainable and representative parameter for estimating the primary stability of dental implants (Bavetta et al., 2019). However, these methods either local objectivity or measure the rotational component of primary stability which is of lesser clinical relevance that the translational component of primary stability (Oliveira et al., 2016). Resonance frequency analysis (RFA) is a widely investigated objective and reliable methods of measuring translational (lateral) primary stability (Chen et al., 2019; Chávarri-Prado et al., 2020). RFA has become an important and widely used tool to measure the implant stability since it can assess this parameter at different time intervals in a noninvasive way, while IT can only be measured at the time of surgery (Machioni et al., 2016; Pimentel Lopes de Oliveira et al., 2016; Chen et al., 2019).

This study presented some drawbacks that must be taken into account when analyzing the data. The conditions of access and ideal positioning of the implants, and the stable standard quality of the area where the implants were installed does not occur clinically, where patients have heterogeneous local conditions. Thus, this study offers only a clue of the pattern of primary stability that can occurs clinically using these types of implants. Thus, it is necessary to performs clinical evaluations in order to assess the implants tested in this study in different bone densities to better understand the effect of the design of these implants on primary stability, and consequently the influence on the osseointegration and success rates.

Conclusion

The implant stability was weakly influenced by implant length or connection, but thicker cortical bone thickness strongly increased the implant stability.

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Figures

Figure 1: The design of the implants placed in this study. A) Conventional-sized implant with EH prosthetic connection; B) Conventional-sized implant with MT prosthetic connection; C) Short-sized implant (5 mm) with EH prosthetic connection; D) Short-sized implant (6 mm) with EH prosthetic connection; E) Short-sized implant (5 mm) with MT prosthetic connection; F) Short-sized implant (6 mm) with MT prosthetic connection. Note that conventional implants, in addition to the differences in platform type, present important differences in the region of the implant neck where the EH type implant has micro-threads and a smooth collar whereas conventional implants with MT connection have a neck without micro-threads with microroughness collar. Short implants have a similar configuration except for the type of prosthetic connection.

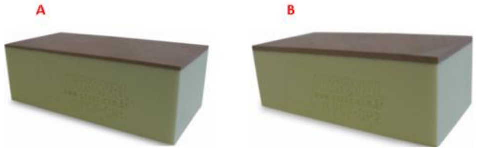

Figure 2 A) Specimen with 1mm of cortical thickness; B) Specimen with 3mm of cortical thickness.

Tables

Table 1: Mean (median) and standard deviation of the insertion torque data of the implants installed in blocks with 1mm and 3mm of cortical thickness.

Implants/Cortical thickness	1 mm	3 mm
4 X 10 EH	43.33 (45.00) ± 2.58^{a}	60.00 (60.00) ± 0.00^{a*}
4 X 10 MT	30.00 (30.00) ± 0.00^{a,b}	42.50 (42.50) ± 2.73^{b*}
5 X 5 EH	26.67 (30.00) ± 5.16^{b}	41.67 (40.00) ± 2.58^{b*}
5 X 6 EH	17.50 (17.50) ± 2.73^{b}	44.17 (45.00) ± 2.04^{b*}
5.5 X 5 MT	39.17 (42.50) ± 9.70^{a}	60.00 (60.00) ± 0.00^{a*}
5.5 X 6 MT	44.17 (45.00) ± 2.04^{a}	61.67 (60.00) ± 4.08^{a*}

Different letters represent differences between the implants within each type of block - Kruskall-Wallis test complemented by the Dunn test ($p < 0.05$); * Insertion torque values higher than those obtained in the same types of implants installed in blocks with 1mm of cortical thickness - Mann-Whitney test ($p < 0.05$).

Table 2: Mean and standard deviation of resonance frequency analysis data of implants installed in blocks with 1mm and 3mm of cortical thickness.

Implants/Cortical thickness	1 mm	3 mm
4 X 10 EH	61.29 ± 2.72^{a}	65.50 ± 1.37^{a*}
4 X 10 MT	62.54 ± 1.26^{a}	66.17 ± 0.58^{a*}
5 X 5 EH	44.92 ± 1.98^{b}	52.21 ± 2.43^{b,c*}

5 X 6 EH	50.58 ± 3.13^{b}	53.79 ± 1.21^{b*}
5.5 X 5 MT	45.88 ± 3.22^{b}	48.42 ± 1.19^{c}
5.5 X 6 MT	48.75 ± 0.59^{b}	54.54 ± 4.61^{b*}

Different letters represent differences between the implants within each block type - One-way Anova test complemented by the Tukey test ($p < 0.05$); * ISQ values higher than those obtained in the same types of implants installed in blocks with 1mm of cortical thickness - Unpaired t-test ($p < 0.05$)

Considerações finais

A espessura da cortical óssea de 3mm proporciona maior estabilidade primária em implantes independente do tipo de conexão e do seu comprimento (Convencional ou Curto) e além disso, os implantes convencionais apresentaram maior estabilidade primária que implantes curtos independente da espessura da cortical com densidade de osso tipo I.

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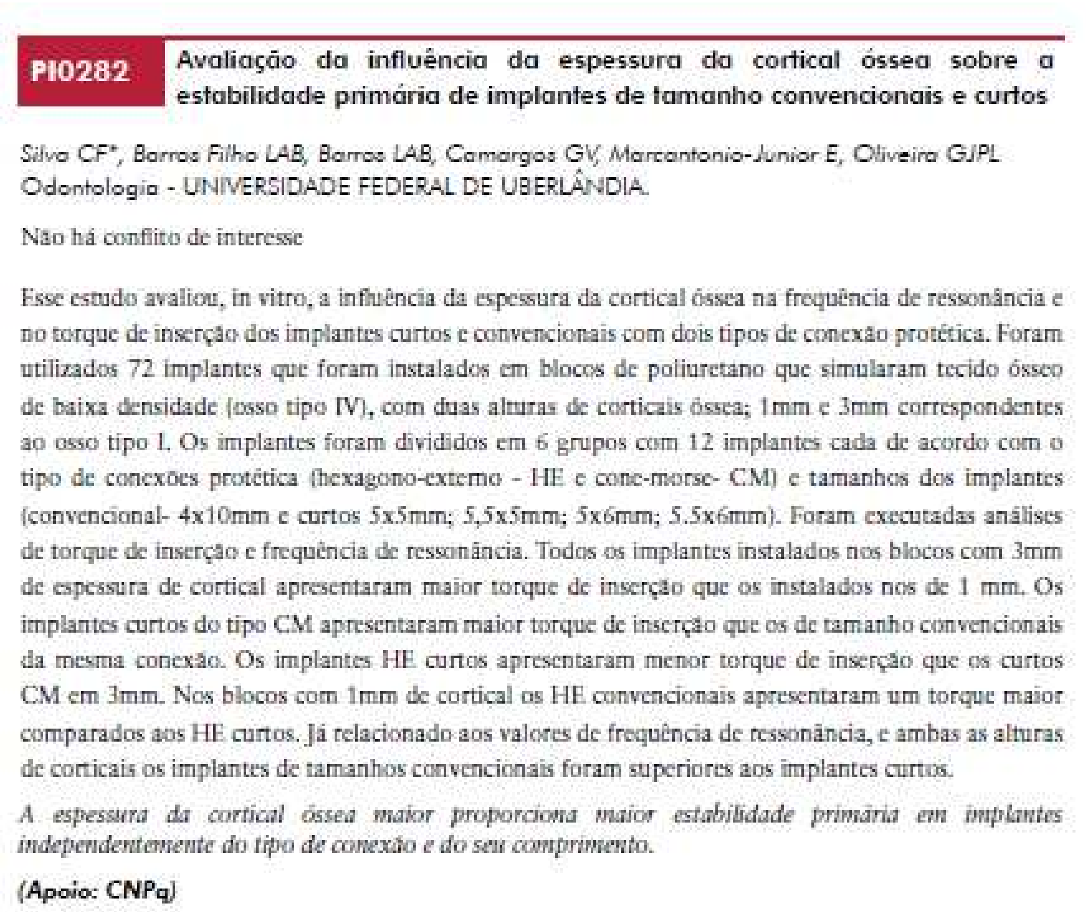
Anexos



PI0282

Avaliação da influência da espessura da cortical óssea sobre a estabilidade primária de implantes de tamanho convencionais e curtos

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Não há conflito de interesse

Esse estudo avaliou, in vitro, a influência da espessura da cortical óssea na frequência de ressonância e no torque de inserção dos implantes curtos e convencionais com dois tipos de conexão protética. Foram utilizados 72 implantes que foram instalados em blocos de poliuretano que simularam tecido ósseo de baixa densidade (osso tipo IV), com duas alturas de corticais óssea; 1mm e 3mm correspondentes ao osso tipo I. Os implantes foram divididos em 6 grupos com 12 implantes cada de acordo com o tipo de conexões protética (hexagono-externo - HE e cone-morse- CM) e tamanhos dos implantes (convencional- 4x10mm e curtos 5x5mm; 5,5x5mm; 5x6mm; 5.5x6mm). Foram executadas análises de torque de inserção e frequência de ressonância. Todos os implantes instalados nos blocos com 3mm de espessura de cortical apresentaram maior torque de inserção que os instalados nos de 1 mm. Os implantes curtos do tipo CM apresentaram maior torque de inserção que os de tamanho convencionais da mesma conexão. Os implantes HE curtos apresentaram menor torque de inserção que os curtos CM em 3mm. Nos blocos com 1mm de cortical os HE convencionais apresentaram um torque maior comparados aos HE curtos. Já relacionado aos valores de frequência de ressonância, e ambas as alturas de corticais os implantes de tamanhos convencionais foram superiores aos implantes curtos.

A espessura da cortical óssea maior proporciona maior estabilidade primária em implantes independentemente do tipo de conexão e do seu comprimento.

(Apoio: CNPq)

Apêndice

Materiais e métodos

Seleção dos implantes

Foram utilizados 72 implantes cônicos (Implacil de Bortoli, São Paulo, SP, Brasil) divididos em 6 grupos de acordo com o tipo de plataforma: hexágono externo (HE) e cone morse (CM) e o comprimento e diâmetro do implante: convencional de 4x10mm e curtos 5x5mm; 5,5x5mm; 5x6mm; 5.5x6mm. Doze implantes de cada tipo serão instalados em blocos de poliuretano com densidade Tipo IV. Os grupos serão nomeados da seguinte forma: ICHE (Implantes convencionais + hexágono externo); ICCM (Implantes convencionais + cone morse); IC5HE (Implantes curtos 5mm + hexágono externo); IC5CM (Implantes curtos 5mm + cone morse); IC6HE (Implantes curtos 6mm + hexágono externo); IC6CM (Implantes curtos 6mm + cone morse).

Figura 1. Kit cirúrgico de implantes curtos (5 e 6 mm) Implacil de Bortoli.

Figura 2. Kit cirúrgico de Implantes cônicos (He, CM).

Figura 3. Implantes Implacil de Bortolli utilizados para realização desse estudo. A) Implante convencional 4x10mm HE. B) Implante convencional 4x10mm CM. C) Implante curto 5x5mm HE. D) Implante curto 5x6mm HE. E) Implante curto 5,5x5mm CM. F) Implante curto 5,5x6mm CM.

Instalação dos implantes

Os implantes foram instalados nos corpos de prova por um único operador, seguindo a sequência de brocas cirúrgicas preconizada pelo fabricante (Fig. 4 a 7). Para reproduzirmos *in vitro* essa avaliação da estabilidade primária dos implantes em condições similares ao tecido ósseo serão utilizados corpos de prova confeccionados em poliuretano (Nacional Ossos, Jaú-SP, Brasil) produzidos em densidade simulando osso tipo IV (15 per cubic foot PCF ou 0,24g/cm^3). As corticais ósseas apresentaram três espessuras diferentes: 1mm, 2mm e 3mm com densidades semelhantes ao osso tipo I (40 per cubic foot (PCF)/0,64g/cm^3). Os corpos foram confeccionados com comprimento (C) de 9,9cm, largura (L) de 2,55cm e altura (H) de 2,02cm, para receber 6 implantes por bloco. No total foram confeccionados 18 blocos distribuídos de forma equitativa entre as diferentes espessuras de osso cortical (1, 2 e 3 mm) (Fig. 10).

Figura 4. Sequência de fresagem para implantes hexágono externo em ossos tipo III e IV.

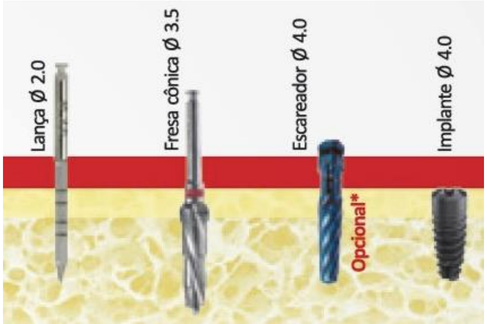

Figura 5*.* Sequência de fresagem para implante cone morse em ossos tipo III e IV.

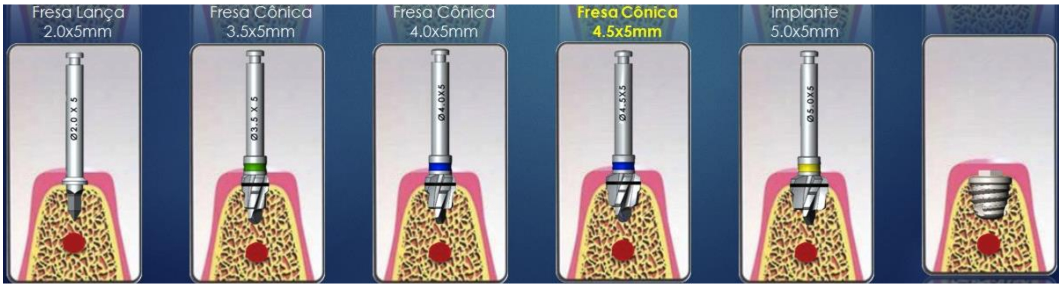

Figura 6. Sequência de fresagem para implante curto hexágono externo em ossos tipo III e IV.

Figura 7. Sequência de fresagem para implante curto cone morse em ossos tipo III e IV.

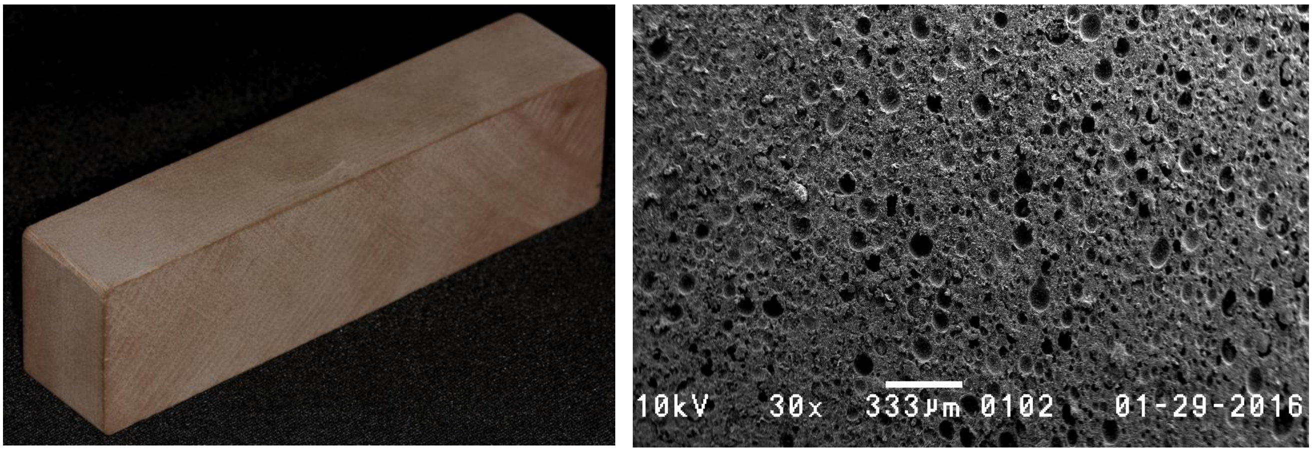

Figura 8. Corpo de prova Nacional Óssos correspondente a coritcal óssea semelhante osso tipo I 40 PCF ou (0,64g/cm^3). Imagem representativo do MEV demonstrando que o corpo de prova se apresentava maciço.

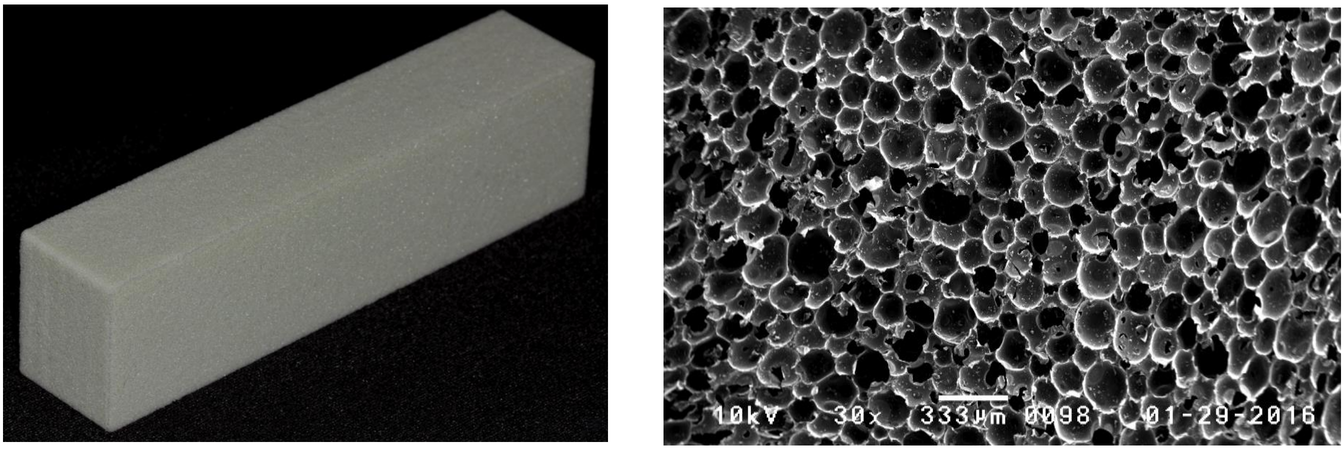

Figura 9. Corpo de prova Nacional Óssos – osso tipo IV 15 PCF ou (0,24g/cm^3). Imagem representative do MEV demosntrando que o corpo de prova se apresentava trabeculado.

Figura 10. Corpo de prova Nacional Óssos – osso tipo IV com três diferentes tamanhos de corticais, 1mm, 2mm e 3mm respectivamente.

Para facilitar a padronização na instalação dos implantes no corpo de prova, um guia cirúrgico foi confeccionado em resina acrílica incolor contendo a mesma largura e comprimento dos blocos permitindo a instação dos implantes na mesma posição e de forma equidistante, mantendo uma distância de 1 cm entre eles e as extremidades (Figura 11).

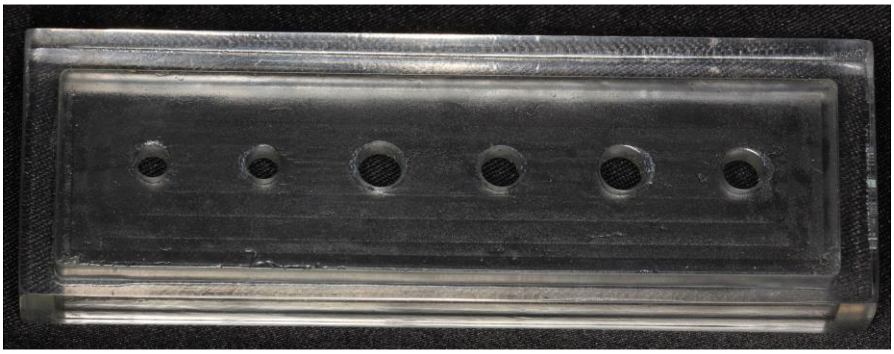

Figura 11. Guia cirúrgico confeccionado em resina acrílica

Avaliação da estabilidade primária: Torque de inserção (TI) e análise de frequência de ressonância (FRA)

A análise de estabilidade primária de cada implante foi realizada por meio do torque de inserção e da análise de frequência de ressonância. O torque de inserção foi mensurado no momento de instalação dos implantes no bloco até que o implante se encontrasse na posição ideal por meio do torquímetro (Implacil de Bortolli, São Paulo-SP, Brasil). A análise da frequência de ressonância foi executada com o aparelho Osstell (Integration Diagnostic, Göteborg, Sweden). Esse aparelho utiliza um efeito piezoelétrico para produzir uma deflexão no implante sendo que o transdutor (smart peg) que será adaptado diretamente sobre o implante será estimulado a vibrar por meio de ondas sinusoidais. A estabilidade medida por esse aparelho mensura em uma escala de 1(mínimo) a 100 (máximo).

Análise Estatística

O software Graphpad Prism 6 (San Diego, CA, EUA) foi utilizado para execução das análises estatísticas deste estudo. Os dados gerados pela análise de frequência de ressonância e de torque de inserção foram submetidos ao teste de normalidade de Shapiro-Wilk. Os dados do torque de inserção não distribuíram de acordo com a normalidade e devido a isso foram analisados por meio do teste não-paramétrico de Kruskall-Wallis complementado pelo teste de Dunn, enquanto que os dados da análise de frequência de ressonância, que se distribuiram de acordo com a normalidade, foram analisados por meio do teste paramétrico de one-way anova complementado pelo teste de Tukey. Todos os testes foram aplicados com nível de confiança de 95% ($p<0.05$).

Figura 12. Osstell - Integration Diagnostic, Göteborg, Sweden.Imagem representativa da análise da frequência de ressonância.